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### RESEARCH ARTICLE

## COMPARING MAXIMUM BITE FORCE FOR DIABETIC PATIENTS WEARING TWO DIFFERENT TYPES OF REMOVABLE PARTIAL DENTURES: A RANDOMIZED CROSS-OVER STUDY

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#### Abstract

**Objective:** This study was carried out to compare the maximum bite force of diabetic patients wearing two different types of removable partial dentures; heat cured acrylic and flexible denture base. The patients were controlled type 2 diabetes mellitus patients (T2DM) having maxillary and mandibular bounded posterior edentulous span (Class III Kennedy classification) opposing each other during different time intervals.

**Materials and Methods:** thirty controlled type 2 diabetic patient having maxillary and mandibular posterior bounded edentulous span (Class III Kennedy classification) opposing each other were selected. Maximum bite forces (MBF) were measured for both polymethyl methacrylate heat cure resin (PMMA) and thermoplastic acrylic removable partial denture by using a portable force gauge. Records were taken one day after delivery, one month and 2 months later for each partial denture.

**Results:** MBF for thermoplastic denture was significantly higher than PMMA denture ( $P < 0.05$ ) as in PMMA denture it was ( $27.2 \pm 3.8$ ,  $30.6 \pm 4.04$ ,  $35.4 \pm 4.7$ ) while in thermoplastic denture it was ( $55.4 \pm 5.9$ ,  $60.2 \pm 4.1$  &  $67.6 \pm 5.1$ ) after delivery, one month and 2 months later respectively.

**Conclusion:** The thermoplastic acrylic partial dentures showed higher maximum bite force than the polymethyl methacrylate heat cure acrylic partial dentures in all recorded time intervals and the maximum bite force was increased in both dentures with increasing the adaptation period.

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#### Introduction: -

Removable partial denture (RPD) used for rehabilitation of lost natural dentition aims to restore patient's masticatory function, speech and esthetics. However partial dentures have less masticatory presentation, bite force than natural dentition about one half to one sixth those of dentate patients, depending on denture type and site and numbers of missing teeth<sup>(1-3)</sup>

Bite force can be defined as "the force applied by the masticatory muscles in dental occlusion". Bite force is produced by the interaction of the muscles of mastication, the maxillae and mandibles, the temporomandibular joints (TMJs), and natural or artificial teeth<sup>(4)</sup>

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Bite force can evaluate the efficacy and function of the stomatognathic system, efficacy of dental prosthesis, or to study effects of defects like malocclusion on the masticatory system and temporomandibular disorders<sup>(5, 6)</sup>.

The devices that measure bite force are mechanical or electrical or both together. The former devices, were mechanical called as gnathodynamometer. In this device weights up to 200 kg were attached to a cord over the mandibular posterior teeth in open mouth position, then patients were asked to close<sup>(7)</sup>.

Nowadays, highly sensitive electronic devices are used to measure the bite force. Recent devices give more precise load measurement. Recent devices can record a force ranged from 50 to 800 N with accurateness 10 N and exactness 80%. These devices use transducers (load cells) to convert force into electrical energy. Types of load cells (force transducers) are strain-gauge transducers, piezoelectric transducers and pressure transducers<sup>(8)</sup>.

Strain-gauge transducers provide accurate measurement of maximum bite force, despite it is still difficult to measure the true maximum bite force due to the possibility of cuspal breaking of teeth and dental prosthesis when biting on the hard transducers<sup>(8)</sup>.

When force is exerted, crystalline material (like quartz) gives charges that is directly proportionate to the degree of force change. The crystals are called as piezoelectric crystals<sup>(9)</sup>.

The pressure transducers comprise a chamber filled with air or fluid. The pressure inside the chamber increases as force is exerted. The increased pressure transferred to pressure gauge for recording. The pressure transducers can be either pneumatic (contain air) and hydraulic (contain liquid)<sup>(10)</sup>.

Some commercially available devices for recording bite force are such as Dentoforce 2 (ITL AB, Sollentuna, Sweden), IDDK (Kratos, Cotia, São Paulo, Brazil), GM10 (Nagano Keiki, Japan), T Scan system (Tekscan, Inc., South Boston, MA), Prescale system (GC Co. Ltd, Japan), MPX 5700 (Motorola, SPS, Austin, TX, USA), FSR No. 151 (Interlink Electronics Inc., Camarillo, CA, USA), MPM -3000 (Nihon, Koudenshi Co, Tokyo) and Flexiforce (Tekscan, South Boston, MA, USA)<sup>(11)</sup>.

Several factors can impact the recording of bite force such as craniofacial morphology, sex, age, periodontal condition, number and position of missing teeth, number and position of opposing teeth, type of dental prosthesis, neuromuscular disease, temporomandibular disorders (TMDs) and the type of measuring devices<sup>(12)</sup>.

Polymethyl methacrylate (PMMA) is the most commonly used material for fabrication of dental prostheses. PMMA provides good aesthetic demands and sufficient mechanical requirements of prosthesis. PMMA has many disadvantages such as difficult insertion in undercuts, brittleness which leads to its easy fracture, and allergy to residual monomer<sup>(13, 14)</sup>.

Thermoplastic dental materials (Valplast and Flexite) belong to polyamides group and were used for dental applications (nylon plastics)<sup>(15)</sup>.

Flexible dentures are an excellent alternate to PMMA dentures, as they have several advantages over the rigid PMMA denture bases, translucency and no clasping provides better esthetics, biocompatibility due to absence of free monomer, strong make it can be processed in thin sections, flexible behavior in undercut areas and flexible dentures that are fabricated by the injection molded technique exhibit better accuracy compared to PMMA<sup>(16, 17)</sup>.

The injection molded thermoplastic resins had less modulus of elasticity, lesser flexural strength and similar or higher impact strength than PMMA<sup>(18)</sup>.

Diabetes mellitus (DM) is glucose, fat & protein metabolism disturbance due to reduced secretion of insulin, resistance to insulin or both. DM was classified into type 1, type 2, hybrid forms, unclassified diabetes and hyperglycemia first detected during pregnancy. Type 2 diabetes (T2DM) accounts for 90% - 95% of diabetes (WHO, 2019). The most clinically important metabolic deviation in diabetes mellitus is hyperglycemia. Long term hyperglycemia are associated with multiple complications such as renal, cardiovascular, ophthalmic, cerebrovascular & peripheral neurological disorders<sup>(19)</sup>.

T2DM is associated with macro- and micro-vascular complications. Diabetic patients are more likely suffering of xerostomia (dry mouth) than non-diabetic ones. Also they have periodontal problems, caries, multiple teeth loss and they need continuous prosthetic adjustments<sup>(20)</sup>.

### **Objective of Research:-**

This study aimed to compare the maximum bite force of diabetic patients wearing two different types of removable partial dentures; heat cured acrylic and flexible denture base.

### **Materials and Methods:-**

#### **Ethical considerations:**

At beginning of the study, patient's data (personal, medical, and dental) were collected according to the implemented principles of research ethical committee of the National Research Centre (NRC), and written consents were obtained from the participating patients. All patients were informed about practical steps of this study and signed approval consent. This study was approved by the Ethics Committee of National Research Centre (Approval No. 16/086).

#### **Materials:**

Heat-cure acrylic resin was obtained from Acrostone Dental & Medical Supplies.

Nylon

(bre.flex2, [http://www.eschoenitz.co.uk/wpcontent/uploads/2019/02/thermopress-400\\_000626GB20180119.pdf](http://www.eschoenitz.co.uk/wpcontent/uploads/2019/02/thermopress-400_000626GB20180119.pdf))

#### **Patients:**

Thirty diabetic patient having maxillary and mandibular posterior bounded edentulous span (Class III Kennedy classification) opposing each other were selected.

Polymethyl methacrylate heat cure resin (PMMA) removable partial dentures were fabricated for each patient. Bite forces were measured by using a portable force gauge. Records were taken one day after delivery, one month and two months later after wearing PMMA partial denture.

Then thermoplastic acrylic removable partial dentures were fabricated for each patient. Bite forces were measured by using a portable force gauge. Records were taken one day after delivery, one month and two months later after wearing thermoplastic partial denture.

#### **Inclusion criteria:**

1. All patients having maxillary and mandibular posterior bounded edentulous span (Class III Kennedy classification) opposing each.
2. Age range 45 to 55 were enrolled.
3. No previous partial dentures experience.
4. Well-developed edentulous ridges covered with firm mucoperiostia.
5. Nonsmokers.
6. Skeletally Angle's class I.
7. All patients were controlled type 2 diabetics for not more than 5 years (i.e. fasting serum glucose level was higher than 126 mg/dl as well as the level of glycosylated hemoglobin (HbA1c) does not exceed 7.5% during the whole study period).

#### **Exclusion criteria:**

1. Neuromuscular disorders and brain diseases.
2. Any medical illness rather than controlled T2DM.
3. Temporomandibular joint disorder.
4. Participant with parafunctional oral habits.

#### **Prosthetic procedures:**

Patient examination was done, including extraoral and intraoral examination, panoramic radiograph, and diagnostic casts.

All patients received finished upper and lower conventional PMMA partial dentures, all required corrections were adjusted as it may affect the records, and they were instructed to maintain satisfactory oral hygiene measures.

Then maximum bite force was measured one day after delivery, one month and two months later.

Then, all patients received flexible partial dentures that fabricated following conventional clinical steps and processed using injection molding technique. Thermoplastic resin (Bre-flex, pink color, bredent, Germany) was cured using thermopress 400 injection molding unit at temperature 260 C and at pressure 5 bar for 26 minutes. After RPD processing, sprues and small flashes were removed carefully and partial dentures were finished and polished using acrylic polishers. RPDs were delivered to the patients and all necessary adjustments were accomplished. All participants were educated and instructed to maintain adequate oral hygiene.

After that, maximum bite force was measured one day after delivery, one month and 2 months later.

#### Measurements of maximum bite force:

A portable occlusal force gauge (GM10, Nagano Keiki, Tokyo, Japan) was used to measure the maximum bite force in the first molar area. Occlusal force gauge comprised of a hydraulic pressure gauge and element for biting that made up of a vinyl material inside a polyethylene tube. The value of bite force was displayed digitally in Newton (N). Its width is 17 mm, height is 5.4 mm and length is 63.5 mm<sup>(21- 23)</sup>.

The specifications of the device are force range(0 – 1000) N, accuracy ( $\pm 1$ ) N, weight about 70 g and size 195 (L)  $\times$  29 (W)  $\times$  18(H) mm.

Before recording the maximum bite force, patient was seated in upright position. The device was placed between the upper and lower artificial teeth and the patient was instructed to bite as hard as possible on the biting element of the gauge. Records were taken three times with resting time 30 second between each record and the mean of these three readings is the maximum bite force (MBF).

Records were taken one day after delivery, one month and two months later.

#### Results:-

Data were presented as mean & standard deviation. Statistical analysis was performed with SPSS 16 ® (Statistical Package for Scientific Studies), Graph pad prism & windows excel.

Independent t-test was performed between two dentures in each record, while comparison between different records separately was performed by One Way Repeated ANOVA, followed by Tukey`s post hoc test for multiple comparisons as presented in table (1) & fig (1).

Comparison between two dentures by independent t-test revealed that MBF for thermoplastic denture was significantly higher than PMMA denture ( $P < 0.05$ ) as in PMMA denture it was ( $27.2 \pm 3.8$ ,  $30.6 \pm 4.04$ ,  $35.4 \pm 4.7$ ) while in thermoplastic denture it was ( $55.4 \pm 5.9$ ,  $60.2 \pm 4.1$  &  $67.6 \pm 5.1$ ) after delivery, one month and 2 months later respectively, as presented in table (1), fig (1).

One Way Repetitive ANOVA was performed in each group to compare between three records and revealed significant difference between them ( $P < 0.05$ ), followed by Tukey`s post hoc test for multiple comparisons which revealed significant difference between 3 records in both dentures (Means with different superscript letters were significantly different  $P < 0.05$ ) as presented in table (1)

**Table 1:-** Maximum biting forces of PMMA denture & thermoplastic denture:

	N	PMMA denture (1)		thermoplastic denture (2)		P value
		M	SD	M	SD	
At delivery	30	27.2 <sup>a</sup>	3.83	55.4 <sup>a</sup>	5.94	0.001*
One month after delivery	30	30.6 <sup>b</sup>	4.04	60.2 <sup>b</sup>	4.147	0.001*
Two month	30	35.4 <sup>c</sup>	4.77	67.6 <sup>c</sup>	5.177	0.001*

after delivery					
P value	0.001		0.001*		

M; mean SD; Standard deviation N; count P; Probability level

\*Significantly different (P <0.05). Means with different superscript letters were significantly different.

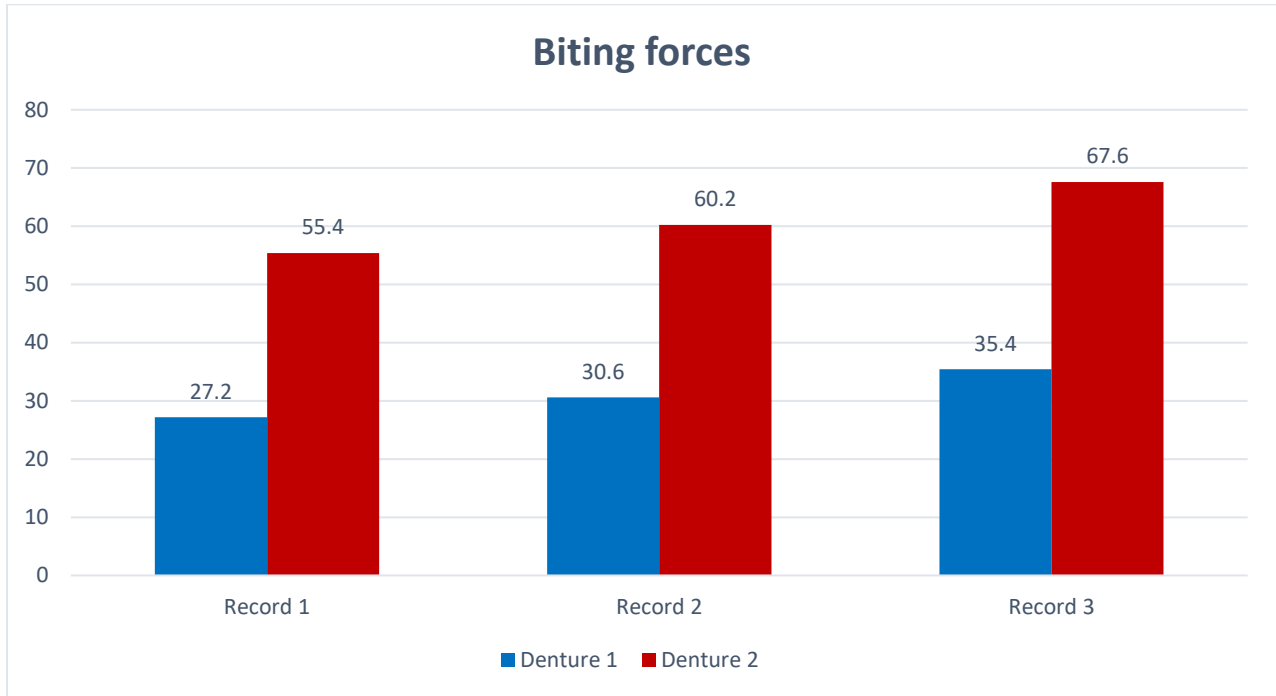


Fig 1:- Bar chart represents biting forces of both dentures at different record intervals.

**Discussion:-**

Patients with controlled type 2 DM were selected in the study due to the increased prevalence of DM, as ~140 million individuals had been reported. Only the controlled diabetic patients were comprised in the study, to maintain blood glucose level nearly close to the normal level because uncontrolled DM showed increasing evidence of chronic oral complications such as caries, periodontitis, oral infections, oral mucosa diseases, teeth loss and faster rate of bone resorption. The more teeth loss, the more MBF reduction <sup>(24)</sup>.

This randomized cross over study was designated to increase accuracy of the statistical results and it is suitable for the variable pattern of teeth loss and the consequently the design of RPD. The cross over design is done for a relatively short follow up period to avoid the possible influence of long time period on residual ridge (such as resorption) and the retention of thermoplastic clasps <sup>(25, 26)</sup>.

The occlusal force gauge has some advantages: simple, easy to use, has a small thickness, does not restrict with the tongue, soft biting element that enables safe, accurate, and comfortable bite force recording without pain or any discomfort experienced by patients during biting, immediate measurement, and easily sterilized by removing the disposable plastic cover <sup>(27)</sup>.

Many studies had reported that replacement of the missing posterior tooth with RPDs markedly improved the masticatory performance, however all of their starting point for data recording was obtained from partially edentulous condition just before the wearing RPDs. The results propose that biting ability after RPDs wearing increased but does not reach the dentulous side. This finding may be attributed to increased activity of muscles of mastication and masticatory performance. Despite, the study subjects had bounded posterior edentulous area with only 2-4 missing teeth <sup>(28, 29)</sup>

The flexible partial dentures recorded higher MBF than PMMA acrylic partial dentures and the differences between them was significant (p < 0.05). Flexible denture base materials were providing equal stress distribution and stress

breaking action that may be attributed to their slight sliding as a result of their inherent flexibility that might allow sufficient normal blood circulation underneath the denture, and therefore, they might reduce the oral soft tissue atrophies<sup>(30)</sup>.

The values of MBF gradually increase as time passes in relation to the initial measurements and this is good indicator of better adaptation to the new partial dentures<sup>(31)</sup>.

### Conclusion:-

Within the limitations of this study, we can conclude that the MBF for restoration of Class III Kennedy classification against Class III Kennedy classification for controlled diabetic patient increased with both RPDs and the increase with flexible removable partial denture was higher than with PMMA partial denture for and MBF increased as the adaptation periods increased.

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